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A decomposition of northern polar external magnetic fields using the method of Empirical Orthogonal Functions

Robert Shore (1), Mervyn Freeman (1), James Wild (2), Gareth Dorrian (2), Jesper Gjerloev (3,4)

(1) Space Weather and Atmospheric Coupling, British Antarctic Survey, UK, (2) Department of Physics, Lancaster University, UK, (3) Department of Physics and Technology, University of Bergen, Norway, (4) Johns Hopkins University-Applied Physics Laboratory, Laurel, MD, USA

We describe our application of the Empirical Orthogonal Function (EOF) method to characterise and separate contributions to the variability of the Earth's external magnetic field (EMF), using ground magnetometer measurements. The method (commonly employed in meteorology) analyses the spatio-temporal co-variance of the data to decompose it into dynamically distinct 'modes'. A small number of these modes can cumulatively represent most of the variance of the original data, with the additional aim that a physical meaning can be given to each mode. Since the basis vectors of the decomposition are defined by the data, the EOF method resolves the spatial and temporal structure of the EMF without a priori assumptions, in contrast to other decomposition methods such as Fourier and spherical harmonic expansions.

We present the results from a case study focusing on northern high latitudes throughout February 2001, using data from 97 observatories and 78 variometers collated by SuperMAG. We have devised a new baseline in order to make the observatory and variometer data comparable, and subsequently binned the data in an inertial frame. Despite the sparse and irregular station distribution, a complete spatial morphology of the EMF is achieved using a self-consistent iterative infill method. The majority (67%) of the variance in our case-study is described by the first four modes. From the spatial morphology and a comparison of the temporal behaviour of these four modes alongside independent measures, we demonstrate that the leading two modes define the well-known DP2 (Disturbance-Polar 2) and DP1 (Disturbance-Polar 1) current systems, and the other two modes describe the spatial motion of the DP1 and DP2 systems.

This practical demonstration is a prelude to producing a model of EMF variations over a whole solar cycle using the full SuperMAG archive from 1996 to 2008.